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Research Project Summary
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Characterization of Hexavalent Chromium Concentrations in Household Dust in Background Areas

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Abstract

In order to understand the significance of the low-level ubiquitous occurrence of hexavalent chromium (Cr^{+6}) in house dust sampled in the Hudson County Chromium Exposure and Health Study in Jersey City, New Jersey, a study was undertaken to measure Cr^{+6} in samples of house dust obtained from background locations unrelated to Jersey City. A total of 20 homes was sampled in New Brunswick, New Jersey and surrounding towns. Three samples were collected in each home and analyzed for Cr^{+6}. Total chromium (Cr^{+6} + Cr^{+3}) was also analyzed in 17% of samples. As in Jersey City, Cr^{+6} was found to be ubiquitous in house dust samples in the background locations. No significant difference was found between Cr^{+6} concentrations in Jersey City and the background locations. Evidence suggests that at least some of the Cr^{+6} in the dust arose from materials inside the houses. Comparison of the correlation of Cr^{+6} and Cr^{+3} in Jersey City and the background locations indicates that residual chromate production waste (COPR) in Jersey City was not a major source of the Cr^{+6} in Jersey City house dust. In addition to household materials, possible sources of Cr^{+6} in house dust include atmospheric deposition, naturally occurring Cr^{+6} in soil, and exogenous soil and soil treatments containing Cr^{+6} contamination. Further research will be needed to identify the sources of Cr^{+6} in house dust.

Introduction

Despite the final or interim remediation of nearly all of the chromium ore production residue (COPR) sites in Hudson County, concern remained among Hudson County residents and particularly among those in the densely populated area of Jersey City that residual contamination remained. In particular, there was concern about possible continued exposure to the carcinogenic hexavalent chromium (Cr^{+6}) in the waste material. In 2006, the New Jersey Department of Environmental Protection (NJDEP) undertook a study in collaboration with the Environmental and Occupational Health Sciences Institute (EOHSI) of Rutgers-UMDNJ to measure Cr^{+6} in household dust as a way of assessing the potential for continued exposure. The report of that study and the associated research project summary are posted on this website at http://www.state.nj.us/dep/dsr/chromium/chrom-exposure-phase%201.pdf and http://www.state.nj.us/dep/dsr/chromium/ respectively. Among the findings of that study was the somewhat surprising observation that Cr^{+6} was ubiquitous, but at low levels in household dust in Jersey City. While the lack of an obvious association of the Cr^{+6} with proximity to known COPR waste sites suggested that this Cr^{+6} might have sources other than COPR, this possibility could not be ruled out. In order to clarify whether and to what extent this was a Jersey City-specific phenomenon, NJDEP, in collaboration with EOHSI, undertook a parallel study of Cr^{+6} in household dust in communities outside Jersey City.

Methods

All of the methods used in this study were identical to those used in the parallel house dust study in Jersey City.

Site selection and subject recruitment

A total of 20 homes were selected in New Brunswick, NJ and surrounding communities (Highland Park, Somerset, North Brunswick). Homes that had been constructed, remodeled, or renovated in the previous 12 months were excluded from the study to avoid a Cr^{+6} contribution from construction materials.

Sample collection

House dust was collected in triplicate from three locations in each house; a surface in a living area (e.g., living room), a window well, and a basement surface (where available). Samples were collected using a pre-weighed filter and a fixed sampling

template. This resulted in a total of 60 wipe samples from the 20 houses. When surface characteristics precluded the use of the template, samples were collected on pre-weighed filters freehand.

Sample analysis

Following extraction with pH 4 nitric acid solution, samples were analyzed for Cr^{+6} by IC/ICP-MS. In addition to Cr^{+6} analysis of all dust samples, 17% of samples were also analyzed for total Cr (i.e., Cr^{+3} + Cr^{+6}). Following microwave digestion with 100% nitric acid, total Cr was analyzed by ICP-MS.

Quantification of Cr concentration and loading

Cr^{+6} and total Cr concentration (µg Cr/g dust) were determined by dividing the mass of Cr determined by the analytical procedure by the total mass of dust collected on the filter wipe. Cr^{+6} and total Cr surface loading (ng Cr/m^2) were determined by dividing the mass of Cr by the surface area that was wiped.

Results

Characterization of background locations

Cr^{+6} was detected in the dust from all homes sampled, with a range 0.05 to 56.6 µg/g (parts per million, ppm). The mean concentration was 4.62 µg/g with a standard deviation of 7.79 µg/g. The concentrations and loadings by community are shown in Tables 1 and 2. Total Cr was analyzed in 10 samples (17% of all samples). The mean ratio of Cr^{+6} to total Cr was 8%.

There was no significant difference among the communities for either Cr^{+6} dust concentration or loading. No significant difference in Cr^{+6} concentration or loading was found among the different types of surfaces sampled (wood, vinyl, laminate, others). The three sampling areas within houses (living area, window wells, and basement), differed significantly from each other with respect to Cr^{+6} concentration, but not loading. The concentration in the living area was significantly greater than the other two areas. Since window well samples mostly reflect dust originating outside the house, this finding suggests that materials inside the house may be a significant source of Cr^{+6} in the house dust. To examine the possibility that older construction and/or furnishings in houses could be a source of Cr^{+6} in dust, the correlation of Cr^{+6} level and house age was examined for each surface type separately. The only significant correlation was found between house age and Cr^{+6} concentration for wood surfaces. This further suggests that older wood material (including furniture) could be a source of Cr^{+6} in house dust. Consistent with this hypothesis, it is known that Cr^{+6} was commonly used in wood stains between 1910 and 1970. In addition, Cr^{+6}-containing CCA wood is a common construction material.

Comparison of background locations to Jersey City

Cr^{+6} dust concentrations in the background locations (median = 2.47 µg/g) were not significantly different from those in the Jersey City study (median = µg/g 2.07 mg/g). Cr^{+6} dust loadings in the background locations (median = 2,912 ng/m^2) were significantly larger than those in Jersey City study (median = 1,982 ng/m^2). However, given the lack of difference in concentration, the difference in loading likely reflects a difference in dust mass *per se* rather than a difference in the underlying sources of Cr^{+6}. When compared by locations inside the houses, the only significant difference in concentration was for window wells with the background locations (median = 1.48 µg/g) higher than Jersey City (median = 0.23 µg/g).

Relationship between Cr^{+3} and Cr^{+6} in background locations compared to Jersey City

Although the comparison of the results from the background locations to those from Jersey City did not suggest significant quantitative differences, it is still important to ask whether the similar levels could have arisen from different sources. In particular, it is of concern whether Cr^{+6} in the Jersey City house dust could have arisen from chromate production waste (COPR) that may still be present in that environment. The data in this study can address this question if it is noted that COPR contains both Cr^{+3} and Cr^{+6}. Thus, if Cr^{+6} in Jersey City originates from COPR, its concentration would be expected to be correlated with the concentration of Cr^{+3} from the COPR. On the other hand, Cr^{+6} in the background locations would not be expected to originate from COPR. Cr^{+3} that occurred along with the Cr^{+6} in the background locations would likely originate from an independent source and, therefore, their concentrations would not be expected to be correlated with the Cr^{+6} concentration. Comparison of the Cr^{+3}-Cr^{+6} correlation from the samples in the background locations to correlation from Jersey City can, thus, provide

Table 1. Cr^{+6} concentration (ppm, µg/g) by geographical location in the study

Town	Homes sampled	Number of samples	Mean	SD	CV	Med	5th percentile	95th percentile	Min	Max
Highland Park	8	24	4.85	4.64	96%	2.89	0.42	15.0	0.16	18.4
New Brunswick	8	24	4.67	11.3	241%	2.27	0.34	10.0	0.05	56.6
North Brunswick	2	6	3.86	4.13	107%	2.17	0.76	11.4	0.76	11.4
Somerset	2	6	4.25	3.81	90%	2.62	1.81	11.8	1.81	11.8
All	20	60	4.62	7.79	169%	2.47	0.35	13.4	0.05	56.6

information about the relative contribution of COPR to Cr^{+6} in the dust samples from Jersey City. As can been seen in Figures 1 and 2, Cr^{+3} and Cr^{+6} were not significantly correlated for either Jersey City ($r = -0.25$, $p = 0.17$) or the background locations ($r = 0.42$, $p = 0.23$) This suggests that the Cr^{+3} and Cr^{+6} did not arise from the same source in either set of locations. While this analysis cannot eliminate a possible contribution of COPR to the Cr^{+6} in house dust in Jersey City, it strongly suggests that COPR was not the major source of the Cr^{+6}.

Table 2. Cr+6 loading (ng/m^2) by geographical location in the study

Town	Homes sampled	Number of samples	Mean	SD	CV	Med	5th per-centile	95th per-centile	Min	Max
Highland Park	8	24	12,698	34,445	271%	4,138	595	44,083	318	169,258
New Brunswick	8	24	10,511	27,786	264%	2,681	495	22,143	252	138,115
North Brunswick	2	6	2,018	1,831	91%	1,255	220	4,450	220	4,450
Somerset	2	6	5,173	4,787	93%	3,544	1,042	13,334	1,042	13,334
All	20	60	10,003	27,886	279%	2,912	407	33,113	220	169,258

Conclusions

As in the house dust study in Jersey City, low levels of Cr^{+6} were found ubiquitously in house dust in the background locations in this study. The levels in both sets of locations were similar and not statistically different. Several lines of evidence suggest that at least some of the Cr^{+6} in the dust arose from materials inside the house possibly including material worn from older wooden furnishings and structural elements. Comparison of the relationship of Cr^{+6} with Cr^{+3} concentrations in the background locations and Jersey City suggested that COPR was not a major source of Cr^{+6} in house dust in Jersey City. This study was not specifically intended to identify the sources of Cr^{+6} in house dust. While some of the Cr^{+6} may arise from household materials, other sources of Cr^{+6} are also possible. These include atmospheric deposition of Cr^{+6}-containing particulates originating local or regionally, and outdoor soil. Cr^{+6} may occur in outdoor soil without a contribution from COPR. Cr^{+6} in soil can occur naturally or may be contained in exogenous top soil (e.g., sludge-derived soil) or soil treatments (e.g., fertilizers). Further study will be needed to identify sources of Cr^{+6} in house dust.

Figure 1

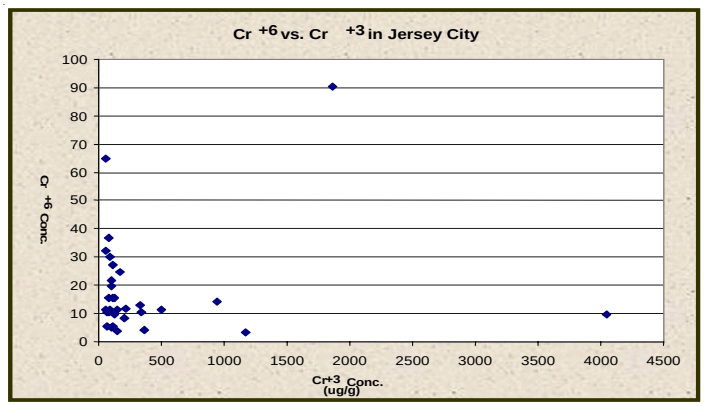
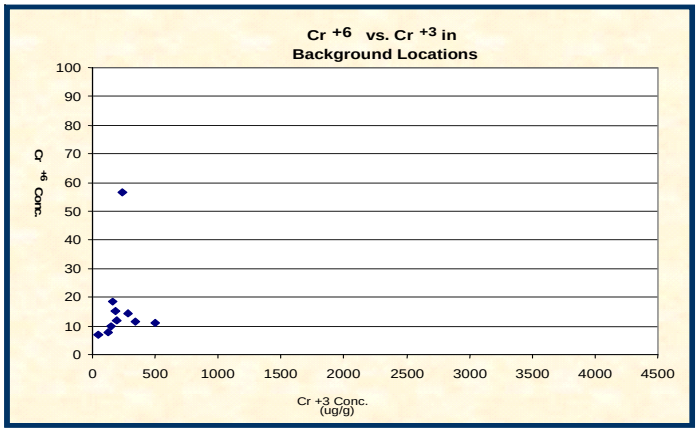


Figure 2



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RESEARCH PROJECT SUMMARY

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